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PHYSICAL IMPROVEMENTS FOR THE RELIEF OF TRAFFIC IN SEVERAL LARGE AMERICAN CITIES

By D. Grant Mickle *

(Presented at a meeting of the Highway Section of the Boston Society of Civil Engineers, held on November 24, 1931)

Traffic engineering is not an exact science wherein one may view the problem at hand and then choose the proper formula for its solution. Each problem in traffic control and regulation is different and requires remedies peculiar to its own particular needs. This is not to say, however, that a great deal of value cannot be gained through learning what has been and is being done to solve various traffic problems in the large American cities. Only by observing remedial measures that have actually been placed in operation can it be learned which ones are inherently wrong and which ones may work again in a similar case.

Every large city has certain problems peculiar to and caused by the congregation of large numbers of people in restricted areas. These problems are most aggravated in the central or business district. In order to narrow the discussion down to manageable size, only those problems directly pertaining to the heavily congested areas will be considered.

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* Mr. D. Grant Mickle, while a graduate student at the Harvard Engineering School and a fellow of the Albert Russel Erskine Bureau for Street Traffic Research during 1930–31, made a study of the adjustment of streets to modern traffic. In June, 1931, with two others he was awarded a traveling fellowship from the Frederick Sheldon Fund of Harvard University to make field studies of the problems they had worked on during the previous scholastic year. The trip, extending from the Atlantic to the Pacific coast, was made by automobile. Fifteen cities were visited, spending three to seven days at each place. This paper gives some improvements made in various cities for the relief of traffic. The complete reports may be seen at the library of the Albert Russel Erskine Bureau for Street Traffic Research, or at the library of the Harvard Engineering School.

Major Problems

The two major problems of traffic control in any city are the expeditious movement of large masses of people into and out of the central district over a comparatively short interval of time, and the free circulation of all vehicles in all places at all times. Were these two problems to be solved in a fairly economical fashion, traffic engineers would have little reason for existence. Since it is unreasonable to expect that these two results can be completely accomplished, we must be content with the nearest approach. Traffic regulation and the necessary attendant physical improvements are costly and can be justified only when they bring about a real monetary saving through lessened delay and congestion.

In this paper are described briefly the problems and relief measures found in several of the largest American cities. No attempt will be made to justify or condemn any particular method or improvement, since only a limited time was spent in any one city, and it was necessary to rely upon information furnished by various officials concerning the efficiency and workability of any particular plan.

New York City

Traffic control and regulation in New York City is vested in the Police Department under the direct supervision of a Commissioner in Charge of Traffic. All physical changes or improvements in street design or layout are handled by the engineers of the various Borough Presidents' offices.

Due to the frequency of the cross-town streets in Manhattan, there are a large number of intersections in the congested area which should have some sort of control. At present only every second or third intersection is signalized. The block system of timing is used, with an attempt to create some sort of progression in an east and west direction. The prevailing custom is for every vehicle to stop at the next cross street when the red light appears, regardless of whether the signal is located on that intersection or on an intersection three blocks away. This system causes confusion to strangers and tends toward disregard and accidents. New signals are being installed as rapidly as money permits. The latest system of lights in Manhattan is that being placed along Fifth Avenue. The posts and housing are to be of bronze and are being cast in the city's own shops. The original design carried an undraped figure of Mercury at the top of the lens housing, but when the Women's Protective Society, or some such organization, learned of the proposed artistic embellishment they at once objected on the ground that the top of the signals would come on a level with the top of the Fifth Avenue busses, and they feared for the morals of the young women of New York. The design has since been altered.

For the protection of street car passengers, safety zones are outlined by stanchions placed in the street. The stanchions are made of 2½-inch pipe set in a concrete base. Usually three are used at each zone, two at the oncoming end, of which one has a hook carrying a lantern, and one at the far end of the zone. At night, when taxicabs fill the streets during the theatre rush, the stanchions are moved to the curb by policemen. Movable zones are especially fitted for New York, in view of the number of parades that pass over its streets every year.

The only two examples of elevated streets in this country are to be found in New York. Park Avenue is elevated around the Grand Central Terminal and passes through the New York Central Office Building. Here is a good example of a street built on railroad air rights, for it is constructed over the tracks of the New York Central. Its greatest value, no doubt, lies in its ability to carry traffic from down town out to the Park Avenue district beyond the Grand Central Terminal without forcing it to mingle with the terminal traffic.

The other example is the West Side Elevated Highway, which is built over 11th Avenue from 14th Street to 23d Street, and which will be continued to 79th Street to connect with Riverside Drive. Traffic coming from the north of New York City enters the elevated street by means of Riverside Drive and then, passing along the edge of the congested district, can enter the Holland Tunnel without having come in contact with the main traffic of the city. It serves as a marginal road which by-passes through traffic and distributes local traffic. Trucks operating along the 11th Avenue wharves are free from passenger car interference.

There are many interesting control problems in New York, but the city is so large and its problems so numerous that time will not permit their description. Alternate one-way streets have gone far in increasing the capacity of the cross-town movement. The unusually large number of cruising taxicabs is a problem difficult to solve. Perhaps they are a necessary evil, but it is certain that if they could be eliminated the streets of New York would seem almost deserted.

The Holland Tunnel carries a large portion of New Jersey bound traffic. Upon emerging on the New Jersey side, traffic passes along a wide one-way street which leads to a depressed street that by-passes the through traffic around the business district. Construction is now in progress on a highway which will carry all of this through traffic headed toward Philadelphia from the depressed roadway on to a viaduct over the Erie Railroad yards, across Hackensack River and out over the Meadows. It will be a high-speed superhighway over which traffic between New York and Philadelphia may pass without so much as passing through the congested district of any town.

Philadelphia

In Philadelphia one of the major traffic problems is narrow streets in the down-town section. The street system is fairly rectangular, with an occasional square breaking the order.

The traffic problems of the city are handled by a Traffic Bureau under the Department of Public Safety. Enforcement is, of course, in the hands of the Police Department.

Signal control of traffic is probably as advanced in Philadelphia as in any city in the country. A new system now being installed is not only designed so as to handle the flow of traffic progressively in each direction along its system, but it is so arranged that various percentages of cycle are used at different times of the day, depending upon the demand. The system automatically gives favor to the inflow traffic in the morning and the outflow traffic at night. During the day a more balanced cycle is used, whereas at night a still different arrangement may be called upon. There are five complete changes during the course of the day, and, should occasion arise that still different percentages should be needed for an unusual condition, the mere pressing of a button in the control room will bring about the desired change. The system will be of the four-corner post, far side, three-color design conforming to the national code.

Because of the narrow streets, safety islands at street car loading points are not very numerous in the congested district. On some of the wider streets wooden platforms are found, but the most common zone is merely a space in front of a pedestal signal light placed a little to one side of the street car tracks and on each side of the cross street.

An experiment in laning is being carried out along Broad Street. The center strip is solid and the 10-foot lanes are separated by dashed lines. Left-turn lanes are indicated at intersections where such a movement is allowed.

One of the few examples of a new street cut through a built-up section is found in Philadelphia. Fairmount Parkway is constructed on a strip of land cut diagonally through several heavily built-up blocks extending nearly a mile from the City Hall.

The rapidly increasing number of pedestrians on the down-town streets is a problem becoming more and more acute in every city. Tall buildings and rapid transits are fast choking the sidewalks. In Philadelphia there is a facility which will help solve this problem. It is a pedestrian concourse located between the subway level and the street level, and extending for several blocks along Broad Street, either side of the City Hall. Subway passengers may enter the concourse from any Broad Street station by means of a short flight of stairs. They are then free to traverse its entire length and are under cover, protected from automobiles, rain, snow, sun or cold. At the time the writer observed this passageway there were only four persons in its entire

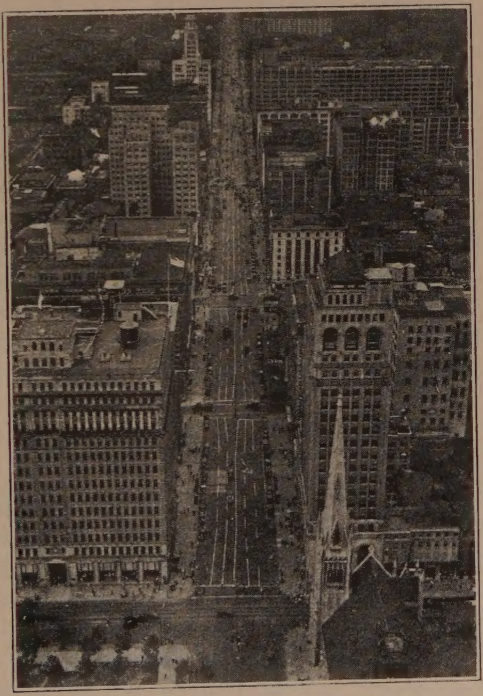

Fig. 1.—Laning on Broad Street, Philadelphia

length, — he and his three companions. Undoubtedly the reasons for its present unpopularity are that as yet stores and offices have not opened entrances at this level, and that the sections on each side of the City Hall are not connected. When these two improvements are made there is little doubt that the subsurface pedestrian passageway will be used by large numbers, thus relieving the surface sidewalks of much of their burden.

Some attempt at street widening by means of arcading the sidewalks into the buildings has been made in Philadelphia. The effort has been confined to two or three isolated buildings, and therefore the results have been rather unimpressive. The new City Hall Annex has the sidewalk along one side arcaded into the building, thus giving an additional 15 feet to Sansom Street for about half a block. At 15th and Market streets a bank building has an arcade around two sides. Such sporadic arcading is of little benefit unless it is carried out in fulfillment of a definite widening plan. It is inconceivable why there has been so little sidewalk arcading in this country, in view of the ease and economy of this expedient in widening overcrowded streets. The arcade has the added feature of providing a shelter for pedestrians as well as offering shaded show windows for delicate fabrics or perishable goods.

Baltimore

In Baltimore signal light erection and timing is under the direction of the Police Department, with the traffic engineers of the street railway company acting as advisors. Due to the modern equipment of the street car company, which allows unusually rapid acceleration of their cars, the progressive signal systems are able to maintain a fairly high rate of speed. In fact, it was reported that the street cars were faster than the automobile traffic, and were often delayed by it in starting.

Streets of irregular width in the business district are a cause of congestion in Baltimore. It is not uncommon to find a street only 35 or 40 feet wide between blocks with 66-foot pavements. This unusual condition is the result of a lack of definite plan following the big Baltimore fire. Because of these irregularities many bottle necks are formed.

Washington, D. C.

Thus far the cities discussed have had their traffic problems accentuated because of the comparatively narrow streets within their business districts. In Washington, D. C., this condition does not exist. The streets are wide and spacious, and many diagonal streets make it possible for vehicles to reach desired areas over the shortest possible routes. The major traffic concern of the Director of Traffic is that of parking. Large numbers of government employees drive to and from work. Because of the lack of provision for parking in the government buildings they are forced to park at the curb. In this city there is a real need for parking facilities within large office buildings.

The diagonal streets superimposed on a rectangular system cause many multi-entrance intersections, at which points traffic circles have often been constructed to advantage. Scott Circle is an example of the intersection of several equally important streets with an artery of major importance. In order to pass the heavy traffic of 16th Street, an inner circle was constructed to allow this through traffic a direct passage through the circle. Signal lights are used to control traffic so that when 16th Street traffic is moving all other streets are stopped.

Pittsburgh

The business district of Pittsburgh is triangular in shape, bounded by rivers on two sides and by hills on the third. With these limiting barriers the district has had little chance to expand in area, but the strategic location of the city has made its growth inevitable. Only a few locations are suitable for traffic arteries in and out of the city. Of these arteries one of the most important and most recently constructed is the Boulevard of the Allies. With the completion of the final plans it will be possible for through traffic to skirt the edge of the congested district, while at the same time vehicles having business down town will be able to enter it by means of a fairly high speed artery. Many bridges across the rivers and tunnels through the hills serve to carry traffic to the west and south over the shortest routes.

One major point of congestion for traffic entering Pittsburgh from the east is at East Pittsburgh. Here the main road comes down what is known as Turtle Creek Hill and deposits its traffic at the front door of the Westinghouse plants. A high viaduct now under construction will span the valley between two hilltops and carry through traffic over the river, the railroad yards, and the congested portion of East Pittsburgh.

Cincinnati

In Cincinnati the traffic department is under the Director of Public Utilities, but the enforcement of traffic regulations is under the control of the Director of Public Safety.

Safety islands are, of course, for the purpose of protecting passengers while they are waiting for or alighting from street cars. The objection has often been heard that the presence of massive obstructions in the street is more of a hazard to motorists than a protection to pedestrians. This may be true if proper warning facilities are not in use. The safety islands in Cincinnati not only protect the street car passenger by means of up-ended street car rails and a concrete buttress at the end, but they also have a Westinghouse Red Head flasher mounted on a steel post set in the concrete pedestal to attract the attention of motorists at night. In addition to this warning there is placed in the pavement, about 50 or 75 feet in front of the zone, an arrow formed by white buttons, calling attention to the driver, who keeps his eyes glued to the road directly over his left-head light, that an obstruction is not far ahead.

A most annoying as well as dangerous habit of motorists is that of turning left or right across several lines of traffic. In order to minimize accidents and delay, many of the entering streets at intersections in Cincinnati are laned for some distance back of the cross walks. White paint lines are sometimes used. On Central Parkway buttons placed in the pavement supplement the white paint lines. On this particular street the words "No Left Turn" are lettered in the right-hand lane; "No Turn" in the center lane; and "No Right Turn" in the left-hand lane. This tends to organize traffic effectively.

The Carew Tower in Cincinnati is a notable example of a building built for modern day requirements. It contains not only a great many shops and a department store, but also a hotel, many floors of offices, and a parking garage for people using the building. In a sub-basement are located loading docks where goods are transferred to or from trucks operating from the larger shops and the department store located in the building. This development is one of the few wherein a conscious effort on the part of building owners has been made to adjust buildings to modern traffic requirements.

St. Louis

St. Louis extends like a fan from a point on the Mississippi River. The older and more congested part of the city is still close to the river front, and so the streets in the business district, as in so many other old cities, are narrow and inadequate for present-day traffic needs. The Traffic Engineer for the city is under the Supervisor of Streets and Sewers, whereas the enforcement of regulations is in the hands of the police, who are under a board appointed by the Governor. Matters pertaining to street widening and opening are planned by the Planning Board and executed by the City Engineer.

Many arterial streets have been widened and resurfaced up to the edge of the business district, where the exorbitant cost halted the work. The result has been that wide, fast streets carry their traffic to the edge of the business district, where it is jammed by the bottle necks. Due to the resulting congestion, delay and inaccessibility, certain businesses, notably theatres and restaurants, are moving from the central area out to a district twenty blocks removed. This decentralization is causing concern in St. Louis business circles, because of the lowering land values and lessened tax return in the central business district. In order to combat this decentralizing movement various subway plans and superhighway proposals have been made. It is hoped that by means of street car subways in the congested area, and a marginal elevated roadway along the river front, traffic congestion may be relieved and decentralization stopped.

St. Louis is the only city visited which did not have a traffic signal system in the business area. All movement during rush hours was handled by police officers.

Los Angeles

The cities of the Pacific coast offer a different picture than those of the East or Middle West. Especially in Los Angeles do we find a difference. Many of the motorists are retired business men, many others are visitors, while a certain percentage are, of course, engaged in business. Because of the large area covered by Los Angeles, traffic movement is very rapid, and, when it is considered that there are enough cars in California so that it would be possible for every inhabitant to go riding at once without it being necessary to use any back or rumble seats, it is evident that the regulation of traffic is no small task.

The traffic signals used are, for the most part, of the city's own design. A red and a green lens are housed in a box which also contains two semaphore arms. The arms move into a horizontal position in accordance with the proper colored signal. At each change of light a bell rings for the purpose of drawing the attention of both motorist and pedestrian. With bells ringing, arms waving and lights flashing, traffic moves or stops, as the case may be. It is the opinion of the authority in charge of traffic that co-ordinated or progressive signal systems in congested areas are not a success because of the delays and stops caused by turning or parking vehicles which thus throw the flow out of step.

Pedestrians in Los Angeles observe the signal lights with the greatest of care. At no time was a person seen crossing the street against a red light. This remarkable discipline was first obtained by very strict police control, and its maintained success is attributed to the ringing of the bell atop the signal box. All cross walks are definitely indicated by paint or button lines, and pedestrians are compelled to cross within these areas.

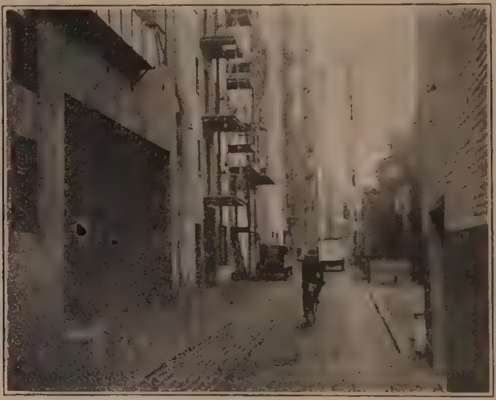

FIG. 2.—LOADING DOCKS IN ALLEY, LOS ANGELES, CALIFORNIA

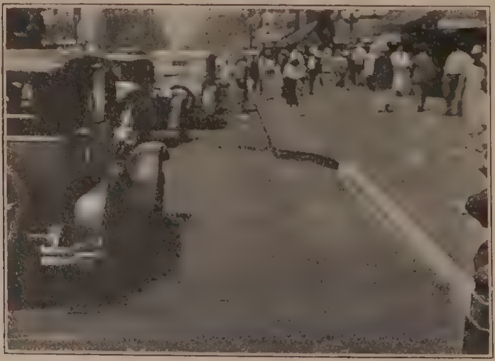

FIG. 3.—PASSENGER LOADING INDENTATION, LOS ANGELES, CALIFORNIA

One of the worst causes of both street and sidewalk congestion is that of trucks loading or unloading from the curb. Maneuvering for a parking position causes obstruction to vehicular traffic, while repeated trips across the sidewalk with goods obstruct pedestrian movement. In

Los Angeles nearly every business block contains an alley. For the most part these alleys are fairly wide and well kept. According to ordinance, every building owner who has a building abutting on an alley is compelled to provide a loading area of specified size. By means of this arrangement all loading or unloading of trucks is taken from the street and placed where it belongs.

The unloading at the curb of passengers from private vehicles or taxicabs has always been a source of confusion and delay, especially on narrow streets or near safety zones. In front of the Pacific Electric Terminal, as well as in front of the Union Pacific Railroad Station, loading setbacks have been constructed so that it is possible for vehicles to draw out of the line of travel while loading or unloading passengers.

Street car loading areas are designated by steel mushrooms outlined by a white paint line. The front mushrooms have red reflectors embedded in them so as to be noticed by drivers at night. In order to draw attention to the approach of the obstruction, a wide white paint line is extended parallel to the outside car rail for 50 or 75 feet before the end of the zone is reached.

San Francisco

In contrast to the spacious area of Los Angeles, San Francisco's business district is confined to a peninsula, with a bay on one side and the ocean on the other. The checkerboard street system of the business district is cut diagonally by Market Street, which is 125 feet wide and carries four street car tracks. The not exactly 45 degree diagonal causes many irregular and difficult intersections requiring islands for the protection of pedestrians and the organization of vehicles. Signal lights in San Francisco are designed and manufactured under the direction of the Electrical Department of the City. Each consists of a box containing a revolving drum placed on a post. A vertical slot in the box on the side facing traffic reveals the word "Stop" or "Go," heralded by the clanging of a gong. In addition to these vehicular signals, each major intersection in the business district has auxiliary electric pedestrian signals. The astonishing thing is that pedestrians in San Francisco pay very little heed to the especially designed signals, whereas in Los Angeles, with no added equipment, the obedience is perfect.

A pedestrian bridge extends across the area in front of the Ferry Building to the sidewalk on Market Street. A vehicular underpass extends under the same area. The bridge is for the purpose of carrying the large numbers of ferry passengers across the heavily traveled Embarcadero. The underpass is to carry the Embarcadero traffic under and past the congestion in front of the Ferry Building. At this particular location we have an example of segregated traffic, — pedestrians above, street cars on the surface, and automobiles below.

Because of many steep hills in certain parts of San Francisco's business section it is difficult for street cars or automobiles to ascend the grade. Cable cars have solved the problem on some streets, but on others it has been found advisable to build tunnels through the hill. Tunnels have made these streets much more easily traveled and have thus caused the central area to be more accessible.

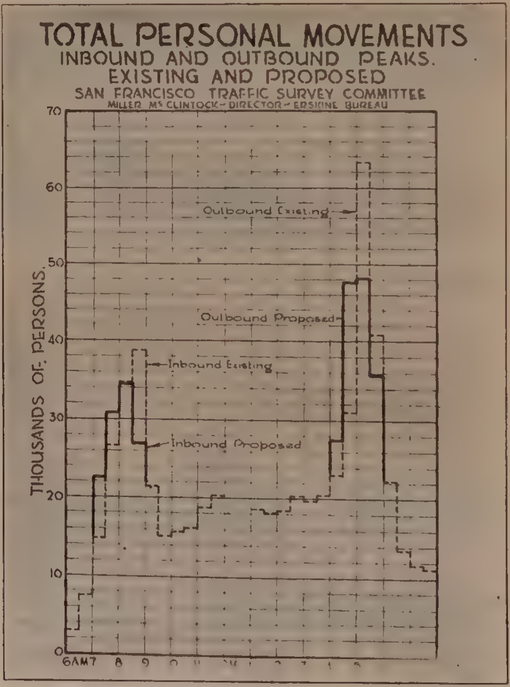

FIG. 4. — PEAK HOUR CHART, SAN FRANCISCO

One of the greatest problems encountered by traffic engineers and transportation men in general is that of providing for the peak rush hours which occur at the opening and closing times of offices, shops and non-retail establishments. It has long been the custom for all stores and offices to open at about the same time, with non-retail establishments preceding them very shortly. It is, of course, the top of the peak which causes the greatest trouble. A slight increase of vehicles over the capacity of a roadway or of passengers over the capacity of transit facilities increases the congestion and delay tremendously. Likewise, a small decrease in these loads, so that the volume is only equal to or less than the capacity of the facilities, brings about a great decrease in congestion and delay. Therefore it is seen that the peak does not have to be leveled off at its mid-point and distributed over several hours, but it will suffice to cut off only those topmost figures of the short period peaks and distribute them, perhaps, only fifteen or thirty minutes either way.

This method of congestion relief was proposed by Dr. McClintock of the Erskine Bureau at Harvard to the Chamber of Commerce in San Francisco. The organization was able to have the opening and closing hours of non-retail and financial establishments shifted enough so that the peak hours were reduced from 38,757 to 30,268 from 8.30 to 9 in the morning, and from 63,382 to 53,382 from 5.30 to 6 in the evening. The plan has been in effect only a short time, but already the street car companies report greatly increased operating efficiency due to faster service, bringing into use of more units of transportation, and fewer costly delays and piling up of equipment. Merchants show a larger business activity nearer closing time, due to more potential shoppers being released a longer time before the stores close. Restaurants have been better able to handle the lunch hour peak, and people are able to get into the central district with less delay.

As yet no other city has attempted this simple, inexpensive, yet very effective method of relieving congestion. It does require a great deal of study and thought to make it successful, for poorly shifted loads may cause greater trouble than good. Doubtless others will follow San Francisco's lead when the merit of the plan proves itself there.

CHICAGO

The number of automobiles in the Loop district in Chicago has increased over that of a year ago, and yet the streets of this perfectly rectangular area never seem crowded, and traffic movement at all times is fairly free and unobstructed. The streets seem unusually free of vehicles, due largely to the absolute restriction of parking within the Loop. The prohibition of left turns at all intersections within the same area tends to reduce confusion and delay. A freight tunnel under the streets connecting all large buildings keeps a great number of heavy trucks from the streets. With these aids the vehicular traffic of the Loop district has been fairly well taken care of.

It is being recognized more and more by highway and traffic officials that through traffic is not wanted in the central districts of cities, nor does it want to go through this district when it has no business there. Much congestion is caused by badly routed traffic. However, few cities are fortunate enough to have suitably located and adequate by-pass routes. Chicago's proximity to Lake Michigan and the inclusion of rivers along the edge of the Loop district offer admirable opportunities for marginal high speed as well as distributing arteries.

One of the most interesting city boulevards is the Outer Drive, built on filled land between the lake shore and the Illinois Central tracks east of Michigan Avenue. As this system of wide, smooth streets is constructed along the shore line, there are naturally no major intersections. At the few cross streets leading to outer points along the shore overpasses have been provided so that for a distance of seven or eight miles south of Grant Park no cross movement or delay is encountered. With the completion of the drive above Lincoln Park on the North Side and the erection of an outer bridge across the river, it will be possible to drive along the water's edge from Evanston, skirting the north side, coming within several blocks of the heart of the city, and going out through Jackson Park into Indiana without encountering a grade crossing at which a stop will be necessary.

From Michigan Avenue, Wacker Drive skirts the Chicago River for about three-quarters of a mile. This marginal road along the northern edge of the Loop is double-leveled. The upper or ground level roadway is a wide, smooth surface, and is valuable in that it provides traffic from the western side of the business district a free and easy passage to the north side without subjecting it to local Loop traffic. The lower level is designed for trucking operations to business houses along the river front. Because of the many irregularities and bays between supporting columns a great many cars are able to park along the edge of the lower roadway.

The inability of motorists to utilize large areas efficiently was demonstrated when the upper level of Wacker Drive was first opened to public use. Where the Drive intersects Michigan Avenue a large triangular shaped area was left free from any obstruction. Traffic tie-ups, accidents and general confusion were prevalent, and the new roadway was not being utilized to the best advantage. It was necessary to block out large areas of this open space before traffic was able to move in a smooth and orderly fashion.

An example of center laning and pedestrian safety islands is to be found on North Michigan Avenue. On each side of the cross streets, and located in the center of the cross walks, are small concrete islands where pedestrians may take refuge.

In front of the Wrigley Building, on Michigan Avenue, a taxicab loading stand in the form of a semicircle is cut back into the wide sidewalk. This indentation is somewhat larger and better protected than the one in Los Angeles.

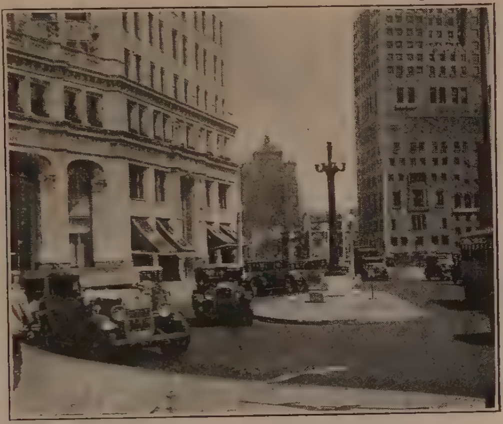

FIG. 5.—TAXICAB LOADING STAND IN FRONT OF WRIGLEY BUILDING, CHICAGO

It is often suggested that pedestrian bridges be built across streets to connect adjacent office buildings. A very attractive bridge covered with Allegheny metal is used to connect the Daily News Building and the Northwestern Railroad Terminal. Taking advantage of a natural

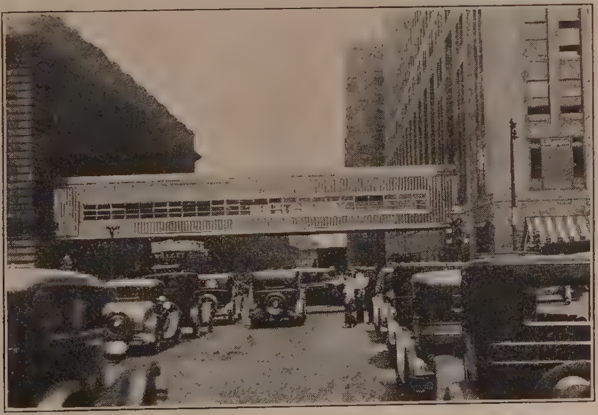

FIG. 6.—PEDESTRIAN PASSAGEWAY BETWEEN DAILY NEWS BUILDING AND NORTHWESTERN TERMINAL, CHICAGO

change in grade, one may go from the entrance of the News Building to the main waiting room of the Terminal across the street by merely passing through the bridge.

DETROIT

Detroit's original plan of diagonal streets superimposed on a rectangular system was disregarded many years ago when rapid growth was of major importance. The result has been a few diagonals converging on a central point in the business district, and a hodgepodge of short, irregular streets in the down-town area. Progressive co-ordinated signal timing is almost an impossibility, but, due to the fact that several of the major streets are wide, traffic is able to move in and out of the central district quite rapidly.

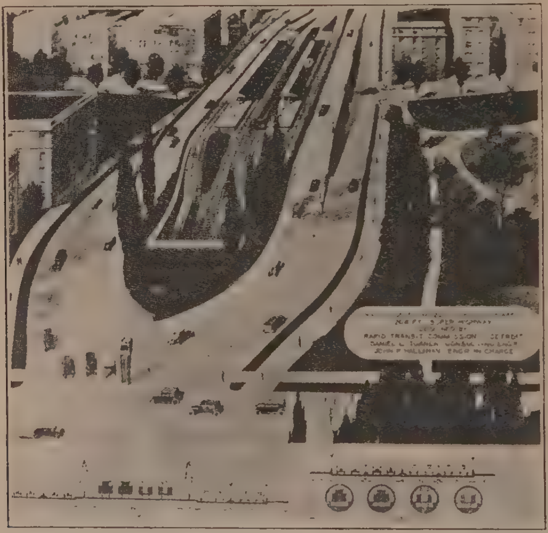

FIG. 7.— PROPOSED DETROIT SUPERHIGHWAY

A plan now being carried out includes in it a series of 204-foot superhighways leading into Detroit, a cross section of which would show two 20-foot roadways on either side of an 84-foot rapid transit right of way. Within the congested areas it is planned to carry the rapid transit lines under ground and narrow the surface roadway to 90 feet between curbs. A double line of local street cars would also be carried on the surface.

An alternate and much less expensive rapid transit plan is that known as the Miller-Schorn Plan. This plan involves the construction of street car loading stations at about one mile intervals for the use of express cars operated singly or in trains. Local service between express stops would be provided by busses. Passage to and from the loading stations would be by means of subwalks extending to the sidewalks, where the bus stops are located. Car actuated trolley switches would operate signalized intersections so as to give continuous passage between stops. Automobiles would not be delayed at loading points, since pedestrians would cross to stations under ground. This plan has been tried in modified form on Jefferson Avenue with a fair degree of success.

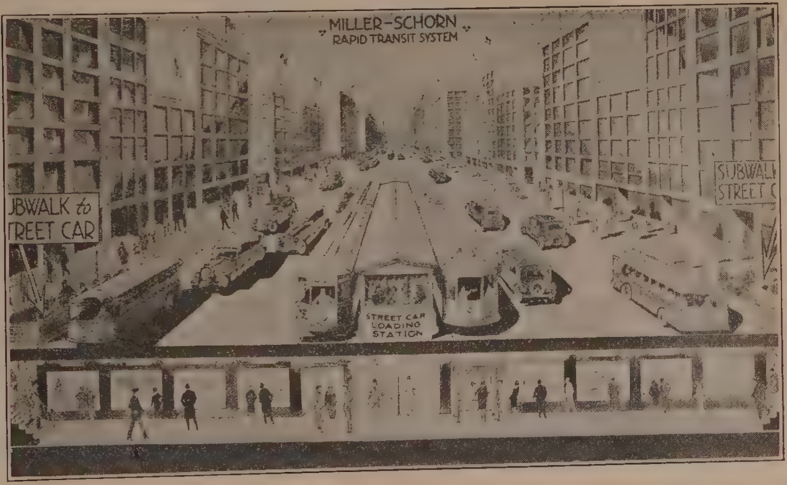

FIG. 8. — SKETCH SHOWING PROPOSED MILLER-SCHORN RAPID TRANSIT PLAN, DETROIT

The stations were placed at the side of the tracks rather than between them, and were covered only by an awning.

Two of the latest safety island developments in Detroit are a movable concrete buttress protected platform and an all-steel movable island. The latter has a steel grillwork floor supported on short legs. A steel railing with a splash-plate along the bottom keeps people from leaving the platform except at the end opening on the cross walk. A flood light on a high standard and reflectors are used for the protection of motorists at night.

Grade separations in congested areas are impracticable because of the maze of subsurface structures, high property damages that must be paid, inability to come to grade within the distance afforded by an ordinary city block, and the lessened accessibility to business on the corner involved. The underpass at Jefferson Avenue and East Grand Boulevard in Detroit is located in a sub-business area some distance from the center of the city. Its possible efficiency is lessened by the operation of signal lights on the surface for the benefit of those few who do not care to use the separation.

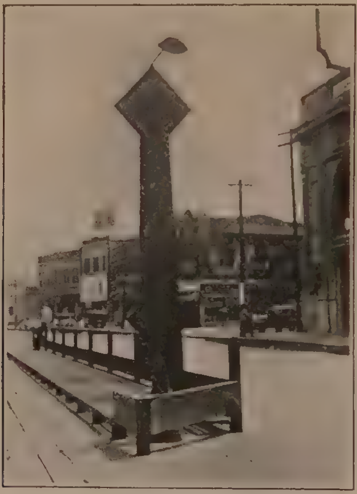

FIG. 9. — ALL-STEEL SAFETY ISLAND, DETROIT, MICH.

CLEVELAND

Much of the morning and evening traffic enters and leaves the business district of Cleveland by means of the Detroit–Superior bridge. The roadway accommodates five lanes of vehicles, and its possible efficiency is increased by alternating the use of the odd lane so as to serve vehicles in the direction of heaviest movement.

Long blocks in the central area have encouraged arcades through the blocks, thus taking some of the pedestrians from the street. The financial worth of these arcades is doubtful, as it was observed that many of the store spaces were vacant.

The yet unfinished terminal group in Cleveland is an interesting self-contained development. In this one project are included railway terminal, hotel, office building, rapid transit terminal, parking garage, department store, and many of the customary shops and stores. Employees or shoppers are able to enter this group either by rapid transit or automobile, and to conduct all of their business without leaving the immediate vicinity. Unnecessary movement and waste of time is greatly minimized.

BOSTON

The traffic problems of Boston were completely outlined in the Mayor's Traffic Control Report of 1928 prepared by Dr. McClintock, and some of the proposed thoroughfare plans were described by Mr. Whitten in his 1930 report. The conditions in Boston are probably familiar, and so I will not dwell upon them.

CAREFUL STUDY OF CONDITIONS NECESSARY

Many cities in the past, when confronted with traffic congestion, have, without much real study of the condition, built costly and, many times, inadequate physical improvements. If the underlying cause of the congestion is not eliminated, the improvement is soon outgrown and more costly changes are needed. It is being realized more and more that by careful and thoughtful study many of the sore spots can be relieved without great expenditures of money. Among the methods being suggested for relieving overcrowded conditions are proper routing of traffic, staggering of opening and closing hours, and strict regulation of parking and loading operations. However, in many cities the proper facilities have never been built. Many plans have been drawn for elaborate systems of multi-deck streets, grade separations, and large underground parking areas. In the more reasonable and probably more workable plans, a system of well laid out rapid transit lines is used to carry the masses of people into the business district. Pedestrian sub-surface concourses are proposed to relieve the sidewalks of their excess burden. A marginal elevated roadway to carry through traffic around the congested area and to distribute vehicles around the business district at points nearest their destination is generally a part of the plan. With these adjuncts provided, the local business streets are left to handle their immediate traffic.

As cities grow and new areas are built more attention must be given to their traffic requirements if congestion and delay are to be reduced.

Discussion

HENRY B. ALVORD:* The talk which we have just heard is in reality a report from a fact-finding commission as to the present traffic conditions in the cities of the United States.

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* Professor of Civil Engineering, Northeastern University, Boston, Mass.

From an analysis of these conditions and from observation of the writer the following points may be of interest:

1. One fundamental principle to be applied to the relief of traffic congestion is that the *stopping* of traffic augments congestion. This point is so simple that it is oftentimes overlooked.

2. The concentration of traffic in arteries is usually undesirable. Multiple parallel roads will generally cause less total congestion.

3. A traffic route should be planned so that there will be approximately equal capacity at all points along the route. Bottle neck constrictions require increased speeds for equal capacity. Since the increase in speed is usually undesirable, the bottle neck has the effect of stopping traffic. Many accidents are caused from the congestion resulting therefrom.

4. Intersecting streets have the same effect as a bottle neck on the flow of traffic. Mr. McClintock states that the usual type of intersection reduces the capacity of either street to 33 per cent of normal.

5. In the interest of safety of operation, operating practice should be revised so that an operator of a vehicle is entitled only to the lane which he is occupying, and should not have prior claim to either of the adjacent lanes to his right or left, even though he be slightly ahead of any other vehicle.

6. I believe it is apparent to any disinterested observer with the least engineering training that street car and vehicular traffic do not mix. The inherently different character of operation of the two types of vehicle seems to support this statement. The substitution of buses seems to be the best solution thus far of this difficulty.

7. In connection with the correct design and operation of traffic signals at intersections I wish to submit the following table.

According to regulations of the Department of Public Works of Massachusetts, a motor vehicle under proper braking control must be able to stop according to the following conditions:

15 m. p. h.	(22.0′/sec.)	requires	20	ft. in	1.83	sec. at decel.	12.0′/sec.^{2}
20 m. p. h.	(29.3′/sec.)	requires	35	ft. in	2.44	sec. at decel.	12.0′/sec.^{2}
25 m. p. h.	(36.7′/sec.)	requires	55	ft. in	3.05	sec. at decel.	12.0′/sec.^{2}
30 m. p. h.	(44.0′/sec.)	requires	80	ft. in	3.66	sec. at decel.	12.0′/sec.^{2}
35 m. p. h.	(51.3′/sec.)	requires	110	ft. in	4.27	sec. at decel.	12.0′/sec.^{2}
40 m. p. h.	(58.7′/sec.)	requires	144*	ft. in	4.88	sec. at decel.	12.0′/sec.^{2}
45 m. p. h.	(66.0′/sec.)	requires	182*	ft. in	5.49	sec. at decel.	12.0′/sec.^{2}
50 m. p. h.	(73.3′/sec.)	requires	225	ft. in	6.10	sec. at decel.	12.0′/sec.^{2}

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* The state gives values of 140 and 180. In order, however, to obtain a uniform value of deceleration the other lengths are used in the table.

This table shows that the Massachusetts Code requiring an interval of three seconds allows just time enough for a car properly equipped with brakes to come to a full stop from a speed of twenty-five miles per hour, and that it can be done properly in 55 feet; also that if an operator is nearer than 55 feet to the intersection he may traverse a distance of 110 feet before the light turns red against him.

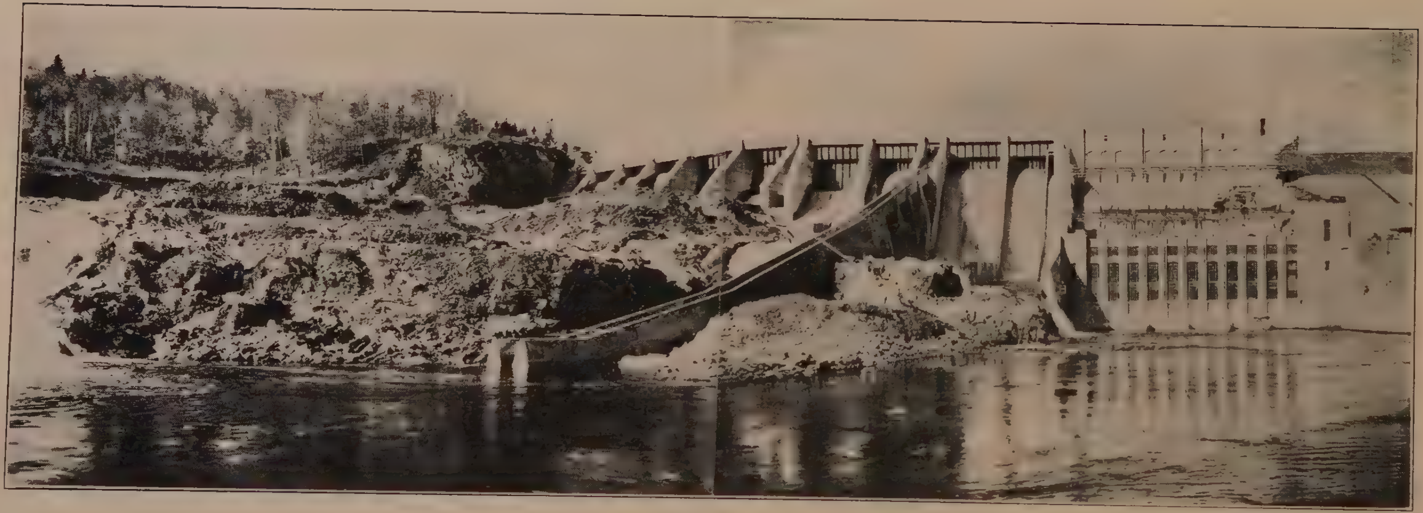

FIG. 1. — WYMAN DAM, BINGHAM, MAINE

(Spillway, log sluice, power house)

WYMAN DAM AND HYDRO-ELECTRIC POWER DEVELOPMENT AT BINGHAM, MAINE.

By H. K. Fairbanks*

(Presented at a meeting of the Boston Society of Civil Engineers on November 18, 1931)

Wyman Dam is the largest hydro-electric development yet built by the Central Maine Power Company, and in many respects it is the largest yet constructed in the New England States. The project is named in honor of Walter Scott Wyman, president and founder of the company, in recognition of his outstanding leadership in the company and business in the state. Starting with the Messalonskee Electric Company, serving one small village with power, Mr. Wyman has guided the growth of the company until now, as the Central Maine Power Company, it serves the entire central and western portion of the State of Maine. In the area served are 296 cities and towns with a population of 316,000 persons. In 1925 the Central Maine Power Company was taken into the Middle West Utilities group.

Capacity of Plant

The total installed capacity of the company system, before adding Wyman Station, was 100,365 horse power, in twenty-three hydro-electric and two steam-electric stations. The total output in 1930 was 292,300,000 k. w. h. Wyman Station will have an ultimate installed capacity of 102,000 horse power, in three units, although only two are to be installed at the present time. The average annual output of the three units is expected to be about 280,000,000 k. w. h. The new station will, therefore, just about double the present total system capacity of generation and output.

Location

The development is located on the Kennebec River, two miles above Bingham, and about twenty-one miles south of The Forks, where the Dead River flows into the Kennebec. The drainage area above the dam is 2,660 square miles. Of this area, about 880 square miles is

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* Engineering Department, New England Public Service Corporation, Augusta, Maine.

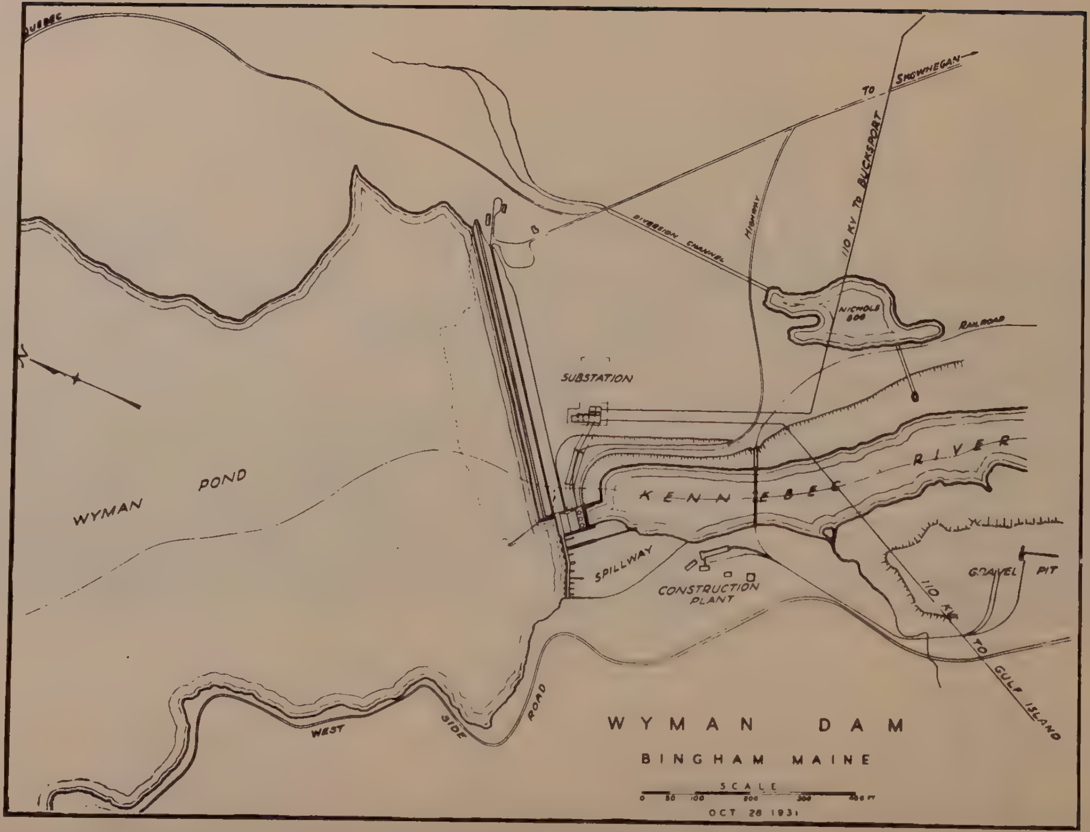

FIG. 2. — WYMAN DAM, BINGHAM, MAINE

tributary to Dead River and is uncontrolled. About 1,200 square miles of the balance is above Moosehead Lake, the outlet of which is fully controlled. The total controlled usable storage above and exclusive of Wyman Dam is thirty-four billion cubic feet. The lake formed by the new structure contains about eight and one-half billion cubic feet, of which two and one-half to three billion are in the draw-down range. The lake is about twelve miles long and over one and one-half miles wide at its widest point.

Geological Conditions

A geological survey of the site was made and extensive drill explorations were carried out. The old river channel was found to be about 500 feet to the east of the present location, and at a depth of 124.5 feet below the existing water surface. The ice sheet which moved down over this area left the entire valley floor filled with stratified drift, some strata of which are very porous and highly water-bearing. Floating ledge and large boulders are scattered all through it, many being two and three yards in size. On the east side of the river, at the dam site, there was a so-called "esker," or terrace. The river bank of this esker stood on a slope of about 1¼ on 1. The material in it was sand and gravel. The elevation of the water surface at the site was 345 feet above sea level.

The ledge is a quartz-schist with a considerable amount of pyrites, and it is hard and durable. The surface is greatly fissured, but the seams are so fine that it was impossible to force any considerable quantity of grout into the several lines of holes which were drilled for this purpose. Ledge outcropped at the west shore of the river and was everywhere near the surface on the west bank. It sloped downward across the river toward the east, dipping gradually to the old creek bed. From that point eastward it rose rather sharply.

General Layout

The layout of the dam includes a non-overflow section of earth 2,400 feet long, which terminates in a massive concrete retaining wall adjacent to the intake and powerhouse. Between the intake forebay and the west abutment is the spillway of concrete founded on ledge.

Earth Dam

Earth was selected for the non-overflow section because of the great depth of ledge below the surface, and because of the very pervious ma-

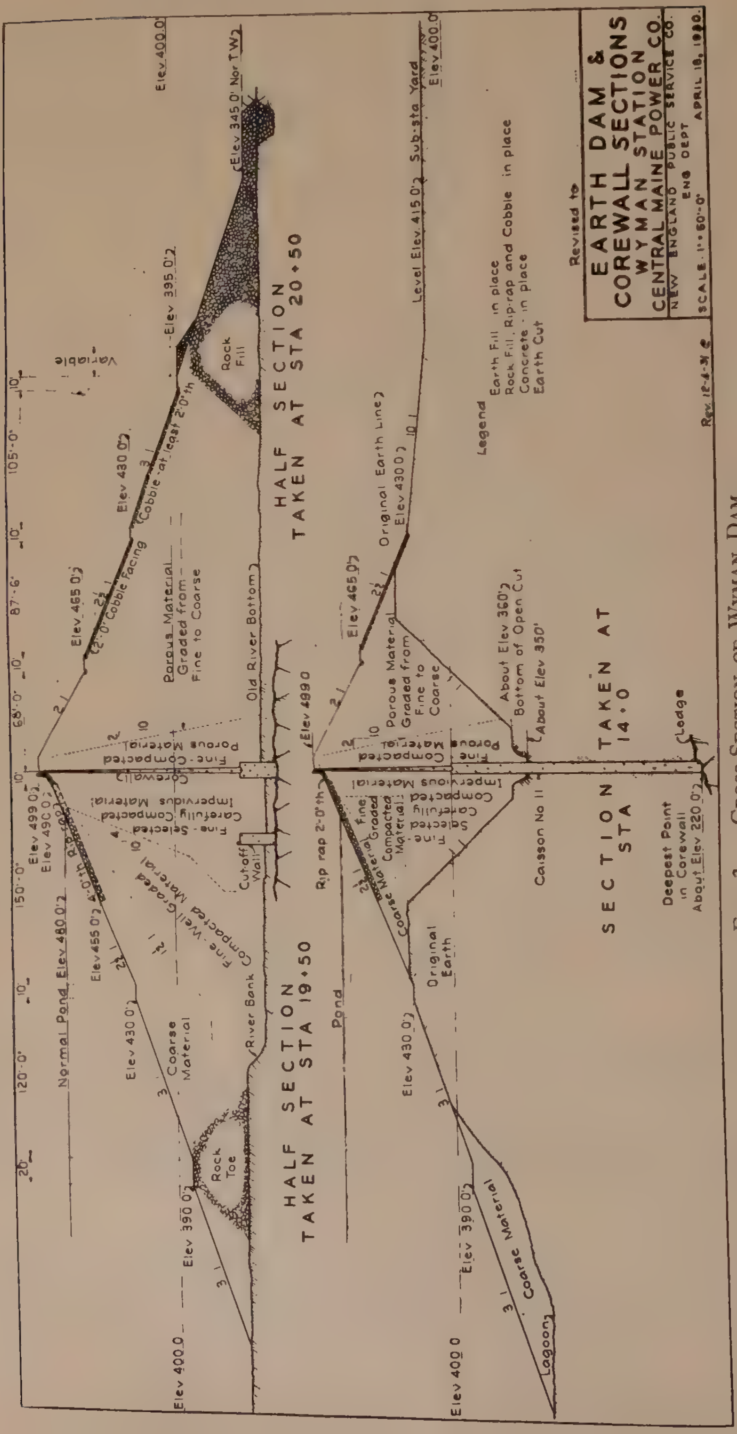

FIG. 3. — CROSS-SECTION OF WYMAN DAM

terial in the valley floor, it was necessary to carry a concrete cut-off wall to ledge for the entire length of the earth dam, except for a short distance on the east end.

Caissons for Core Wall Construction

This core wall was extended to Elev. 494. Attempts to drive steel sheeting for open trench excavation resulted in failures, due to the presence of the large boulders and ledge, hence pneumatic concrete caissons were found to be necessary to reach ledge at its deepest points. An 80-foot open cut to Elev. 350 was made through the esker before the casings were started. The caisson sections used were, in general, 40 feet long by 8 and 12 feet wide, and solid, except for the working chamber and a 48-inch diameter steel-lined shaft which extended from the working chamber to the top. The sections were built with concave ends and were set to leave a space of about 18 inches at the edges. The space so formed was excavated and filled after the main sections had been sunk to ledge and filled.

Earth Dam Cross Section

The crest of the earth fill is at Elev. 499, giving a 19-foot freeboard over the normal pond level at Elev. 480. The top width of the earth crest is 12 feet. The upstream slope is 2½: 1 from the crest to Elev. 430, below which the slope is 3: 1. One berm 10 feet wide is located at Elev. 430, and another one 20 feet wide at Elev. 390. The downstream slope is 2: 1 to Elev. 465, 2½: 1 to Elev. 430, and 3: 1 below that level. A 10-foot berm is built at Elev. 465 and one at Elev. 430. At Elev. 395 there is a bench 30 feet wide on which are located a driveway and railroad track serving the powerhouse.

Most of the two and one-half million cubic yards of material for the earth dam was excavated from the plateau south of the dam on the east side of the river. It was loaded by shovel and dragline into the hauling equipment, which consisted of Linn tractor-trucks, auto trucks, and tractor-drawn bottom dump wagons. The material was spread in thin layers by bulldozers, and compacted by the travel of the hauling equipment and heavy rollers. Sprinkling was done to insure proper compacting when the moisture content was low. By working several pits and careful supervision of distribution an excellent grading of material in the dam was obtained. Clayey material for the impervious sections was obtained from pits about a mile south of the site on the west side of the river.

Rock for the toe fills and riprap was taken from the excavation in

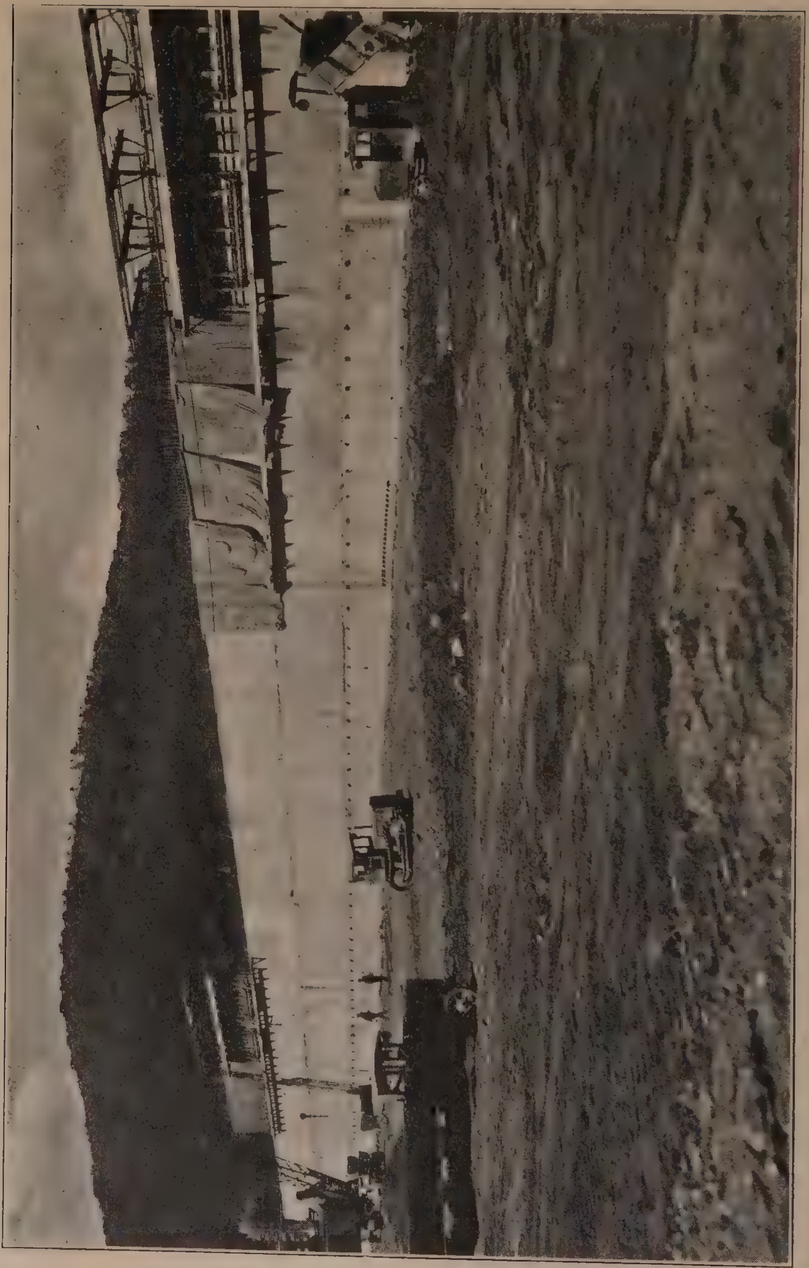

Fig. 4. — Core Wall and Earth Fill

the powerhouse and tailrace, and from the excavation on the west bank for the spillway.

RETAINING WALL

The retaining wall which terminates the earth fill is 975 feet long and 165 feet high. It contains 82,000 cubic yards of concrete. It is battered 3 on 10 on both faces. The face next to the earth fill is saw-toothed, with the grooves set at an angle of 45 degrees, all faces being sloped so that the earth in settling will hold against the concrete and not drop away. To further prevent the flow of water along the contact surface between fill and wall, a series of fins were built to project 5 feet into the fill. The layout was made so as to provide that rolling and tamping equipment should be able to get in close to insure as tight placing of material there as elsewhere.

Double lines of grout holes were driven on each face, with the tops of the pipes brought up into the drainage tunnels. Ledge drains have riser pipes to the drainage tunnels also.

CONSTRUCTION JOINTS AND DRAINS

Construction joints in this wall as well as in the forebay wall and spillway are drained in a unique manner. Two lines of open holes were formed on each wall face at each vertical joint. Heavy walled rubber hose was used for the forms. They were cast into the concrete and later removed by pulling with a block and fall, or by a derrick when one was available. The form used was 4-inch outside diameter. The outside line, 4 feet from the face of the wall, was filled with hot asphalt. The second line, located 2 feet inside the first line, was left open and carried to the drainage tunnel. In addition to this, two lines of water stops, 2 inches by 6 inches, and filled with Genasco, were placed 18 inches and 3 feet from the faces of the wall on all vertical joints.

On the horizontal joints a steel plate ⅛ inch by 10 inches was set 5 inches into the top of each pour, in line and connected with the asphalt filled vertical stops. Back of this and connecting with the open 4-inch vertical line was placed a cross drain. This was open-joint tile packed in washed gravel. It was plastered over before concrete was placed, to guard against plugging. That the system is effective is attested to by the fact that the total seepage during the winter of 1930–31, when the joints were open a maximum amount, and before they had silted up, was never in excess of 2½ c. f. s. This was for the entire retaining wall and intake, all of which drains are brought together in the inspection tunnel.

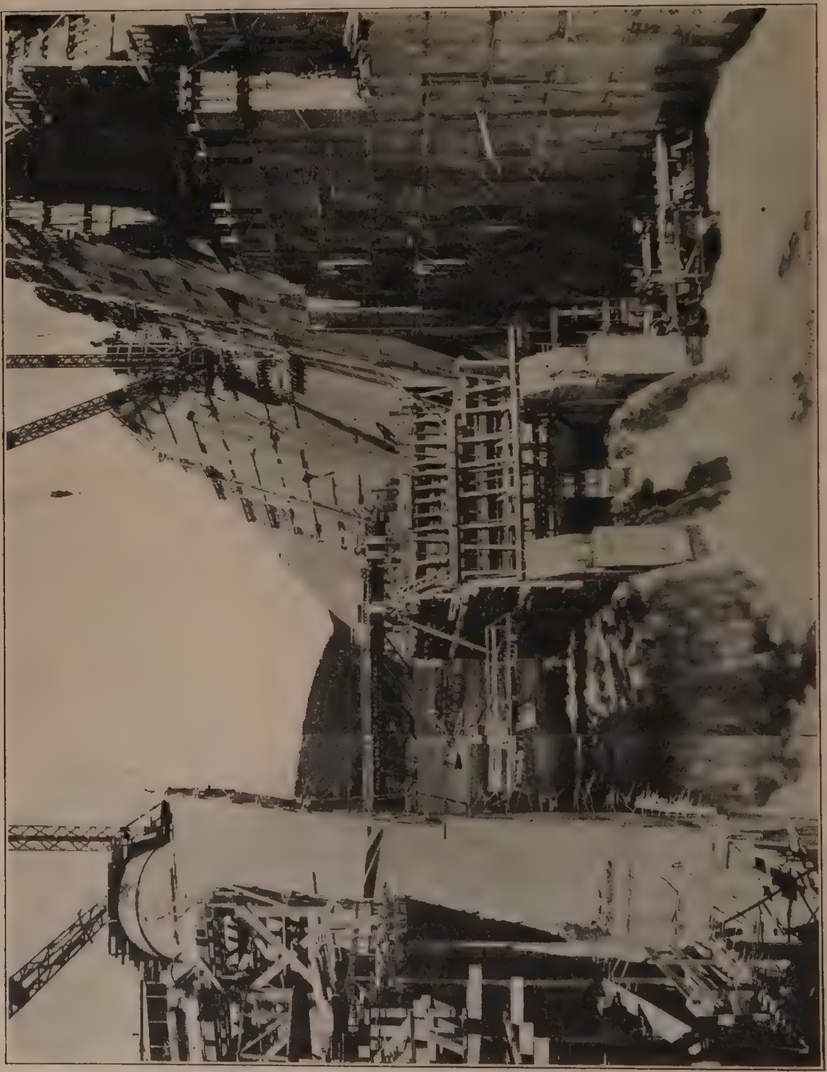

Fig. 5. — Construction on Line of Retaining Wall

SPILLWAY SECTION AND GATES

The spillway is a gravity, ogee section, with the entire length controlled by crest gates. For normal pond regulation the gates used are Philips & Davies Broome type gate, 20 feet by 20 feet, electrically operated. Electric strip heaters are provided to keep this gate clear of ice in freezing weather.

Three tainter gates, each 20 feet high by 30 feet long, are operated electrically and controlled at the hoists. Three bays of stanchion gates carrying 10 feet of head occupy a total net length of 115 feet. These are designed to trip and be pulled back.

Three bays, each 45 feet in the clear, are equipped with stanchion gates carrying a 24-foot head. These are for emergency use and are designed to trip and be lost. The top 6 feet of boards below pond level on all stanchions are in panel form and equipped with hand-operated hoists.

LOG SLUICE

A log sluice is provided for handling the 250,000 cords of pulp and saw logs that are driven down the river each spring and summer. Considerable study has been given to this sluice, and it is possible in the layout provided to sluice logs at the rate of 2,500 cords each twenty-four hours, and use not over 100 c. f. s. This compares with a use of from 400 to 800 c. f. s. in existing sluices elsewhere.

SPILLWAY CAPACITY

The spillway has a discharge capacity of 246,000 c. f. s., with pond at Elev. 495. With the pond at Elev. 485 the capacity of all openings is 140,000 c. f. s. The greatest known flood at this point on the river was about 65,000 c. f. s., in 1901.

Compressed air pipes are placed along the entire length of the spillway to prevent ice formation. Air will be supplied at a pressure of 20 pounds per square inch, after being treated to prevent freezing in the pipes.

For handling stop logs, stanchion spindles and other general purposes on the bridge level, a traveling jib crane of 12,000 pounds' capacity is provided.

CONSTRUCTION SCHEDULE

The first work done was on the core wall and caissons on the east bank. Next, the retaining wall and powerhouse were started so that the river could be diverted from its old channel. It was impossible to use a diversion tunnel because of the necessity of passing the log drive each spring and summer. It was also necessary to have the first diversion waterway at a low level because the construction of the earth dam in the old river channel would not permit of raising the pond level.

To take care of these conditions and limitations the entire powerhouse area was brought up to the underside of the wheel scrolls, and the westerly unit was carried up to full height. The head wall and intake for this unit was also constructed. This left a channel about 90 feet wide to carry the river.

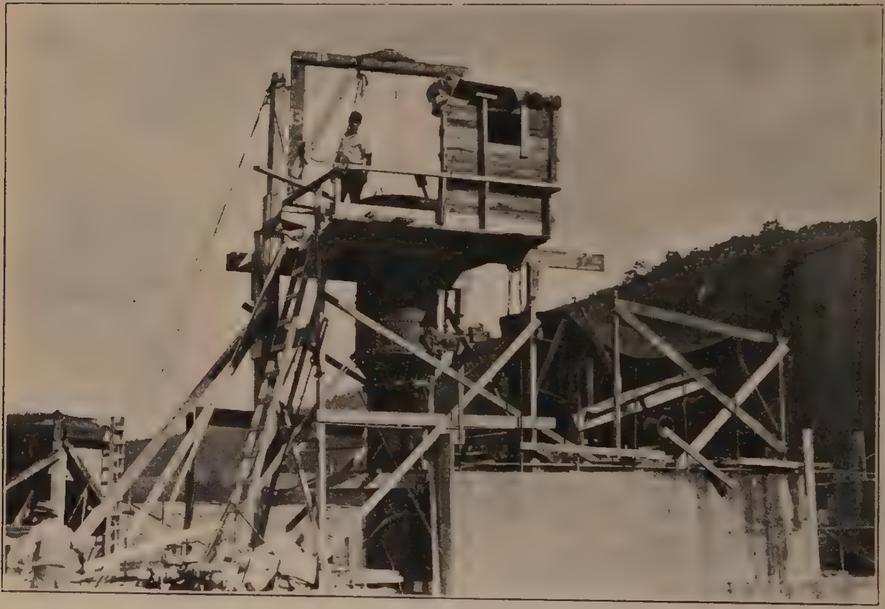

FIG. 6. — AIR LOCK ON KEY SECTION

(Between main sections Nos. 13 and 14)

When the earth dam had been built to a sufficient height, the first diversion channel was closed and the pond raised until the flow could be carried through openings in the spillway section west of the powerhouse.

This method of construction complicated work on the powerhouse, but it was the best that could be done under the circumstances.

WATERWAY ENTRANCE TO TURBINES

The waterway entrance to each turbine is flaring, with a center dividing pier. Welded trash racks protect each entrance. These are made up of 6 inch by 5/8 inch round edge bars, spaced 5 inches on centers. They are made up in panels of 7 feet 4 inches by 28 feet 6 inches.

Each half of each waterway is controlled by a gate, 11 feet 1 inch wide by 22 feet high. At a point 22 feet beyond the gates the passages converge to a circular section 16 feet in diameter. Between this point and the scroll cases the penstock is uniform in section and steel lined.

FIG. 7. — LEDGE UNDER CAISSON
(Section 13)

The head gates are the Philips & Davies caterpillar gates. Each is operated by a Philips & Davies stationary electric-driven cable hoist of 65 tons' capacity, with remote control from the main switchboard.

The hoists are equipped with up-and-down limit switches, and with position indicating lights on the switchboard. They are located in a chamber below the deck level. Removable slabs over each gate permit the removal of any, if such might be necessary. By locating the hoists inside, the entire mechanism is protected from the weather, and maintenance expense is thereby reduced.

POWERHOUSE

The powerhouse design is somewhat out of the ordinary. The superstructure has been eliminated, and instead, a concrete deck covers the entire area at Elev. 395. Over this slab is placed a waterproofing membrane, on top of which is poured a reinforced concrete wearing slab. A removable glass hatch, octagonal in shape and providing a clear opening of 21 feet 6 inches, is located over each unit. In addition a service hatch 10 feet square is provided.

Entrance to the station is had by a stair tower. This leads to the control room which extends across the south face of the building. The control room is 14 feet 6 inches wide and 103 feet long. In it are the main control and relay boards.

The generator room is 33 feet wide by 155 feet long. In it are located only the generator units. A small service crane of 16,000 pounds' capacity runs the length of the room. It is capable of handling all small parts of the units. It is possible to do practically all repair work on the units without having the hatches uncovered.

A two-leg outdoor Gantry crane, with a span of 49 feet 7 inches, travels the length of the powerhouse and serves all the hatches and the erection space on the roof. The railroad and roadway are brought on the roof under the crane so that all equipment can be unloaded from the cars and set in place. The crane is all electric with two trolleys, each of 62½ tons' capacity.

The draft tubes are the improved elbow type cast in the mass concrete of the substructure. A short steel liner is placed below the discharge rings.

The scroll cases are drained by 24-inch diameter pipes through an unwatering pump. The bottoms of the scrolls are 3 feet below the normal tailwater level, and provision is made for applying compressed air to hold the water down during inspection and repairs. Stop log guides are provided in the tailrace piers to allow unwatering of the draft tubes.

There are two units installed at present, with provision for a third. The parts that are cast in concrete are already installed for the third unit.

TURBINES

The turbines are Allis-Chalmers make and are vertical shaft, Francis type, set in steel scrolls. They are rated at 34,000 horse power, each under a net head of 135 feet and at 138.5 r. p. m.

The turbine guide bearing is babbitted and oil lubricated. Normally the oil is supplied by a gear-driven pump, but a motor-driven pump automatically furnishes oil to the bearing while starting up, and in case of a failure to the main pump.

Removable wearing rings are provided on the runner and portions of the cover rings which are immediately adjacent to it.

The governors were also made by the Allis-Chalmers Company. They are of the oil pressure actuator type and are arranged for starting or stopping the units from the switchboard as well as from the governor stand. The fly balls are motor driven. The unit system of pumps, pressure and sump tanks is used, although a small-sized cross connection is installed between units to permit any unit to be closed if its oil system should fail. All of the governor equipment is located in the basement away from cold air.

The shaft is of one piece instead of being split between the generator and wheel as is the usual custom. This is possible on account of the two-hook Gantry crane, and eliminates certain possible chances of misalignment. The complete shaft was furnished by the Allis-Chalmers Company.

GENERATORS

Directly connected to the shaft of each turbine is a General Electric generator rated at 24,000 k. w., 26,667 k. v. a., .9 p. f., 13,800 volts, 3 phase, 60 cycles. They are the umbrella type, with General Electric compressed spring thrust bearings located below the rotor, and have only one guide bearing each. In this type of construction the weight of the rotating parts is carried on a short bracket below the rotor, and does not have to be transmitted through the stator. The complete weight of the rotating elements plus water thrust is slightly over one-half million pounds. Another important advantage is that no oil from leaks can get to the rotor or stator windings; also the rotor may be removed, allowing access to the windings without disturbing the thrust bearing. There is ample space available, and provision has been made to replace a damaged bearing part by lifting the rotating parts only about three-quarters of an inch. The rotor consists of a structural steel spider with radial arms of a fabricated beam section, outside of which the rim is built of segmental punched sections of thin steel plates.

The main exciter and pilot exciter are at the top of the machine on an extension to the main shaft. The pilot exciter armature is tapped and leads brought out to provide a source of power for the governor fly balls.

The machines are ventilated by taking the cold air in through the top and passing it out through the space within the stator frame to a duct which discharges above the roof of the powerhouse. A damper and second exit is provided, so hot air can be taken in to the basement and recirculated during cold weather. Instead of the usual ventilating duct around the stator, this duct is within the stator, between the outside frame and the iron for the core. The frame is set slightly eccentric so as to allow more air area near the exit.

To provide for stability when connected to present or future transmission systems the generators were designed with low transient reactance, large WR^2 damper windings, quick response excitation, and a high speed, rheostatic type, automatic voltage regulator. The short circuit ratio was made higher than usual in order to permit one generator to charge a long transmission line.

Both ends of each phase are brought out for differential protection and the neutral of each machine to solid ground. There are no auxiliary or house generators. Each unit furnishes all the power required for its own operation. The station service power is taken from a bank of transformers on the 110 k. v. bus.

Switchboard and Transformers

The switchboard was furnished by the General Electric Company. In order to save space it was placed flush with the control room wall, access to the rear being obtained from the generator room. There is one panel for each unit with a separate panel for the exciter equipment.

A General Electric Warren type frequency control is installed at this station.

Between the powerhouse and the dam is a space in which are located the 13.8 k. v. cell rooms, a storage battery room. transformer oil coolers, air compressors, oil storage, machine shop, and spare parts storage.

The only low tension switching is the disconnects in the cell room for transferring the spare transformer to any unit. The generator leads are also tapped here for a source of power for the unit governor oil pump and other unit auxiliaries.

All transformers and oil circuit breakers, including the unit service and station service apparatus, are placed outdoors, thereby eliminating all fire hazard from this class of apparatus.

The space over this bay is utilized for the unit switching and main transformers. The line switching is accomplished in a substation about 500 feet from the powerhouse.

A study of the line diagram shows one oil circuit breaker for each bank of transformers, and one for each line, plus one breaker for a bus tie. Each breaker has an airbreak by-pass switch and isolating disconnect switches. There are two busses, and each breaker is connected to them through motor-operated selector disconnect switches. These selector switches are interlocked with each other and with the oil circuit breakers, so it is impossible to operate them in the wrong sequence.

Each unit has its own bank of three single phase transformers, and there is one spare transformer for the station. They are Westinghouse make and are rated at 8,889 k. v. a. each 13.2 k. v. to 115 k. v. with taps. On account of the small space available for them they were made of the forced oil cooled type. The hot oil from the transformers is pumped through Griscom coolers through which water from the pond flows by gravity. It is arranged so there is always a positive pressure of 10 pounds or more of oil to water, thus eliminating all possibility of water getting into the oil. The transformers are connected delta on the low side and star on the high side, with the neutral solidly grounded. The single-phase, 500 k. v. a. transformers in the line switching yard step power down from the 110 k. v. bus for station service, and provision is made to feed the local town of Bingham from these transformers.

The circuit breakers are the Westinghouse Deion Grid-type, and have an interrupting capacity at rated voltage of 1,500,000 k. v. a. Each breaker is equipped with bushing type current transformers for relaying, and the line breakers have additional current transformers for ammeters. The line breakers also have bushing type potential devices for relaying, synchronizing, potential for voltmeters and power-factor meters. The opening time at full rated k. v. a. from energizing the trip coil to the rupture of the arc is 12 cycles.

LIGHTNING ARRESTERS

The lightning arresters are also Westinghouse make and are rated at 121 k. v. maximum with solidly grounded neutral. As a back-up to the lightning arresters fused ground gaps are installed. These gaps are constructed so the fuses may be replaced at any time without killing the line or removing any other piece of equipment from service. They are supposed to clear in not over 1½ cycles, and the line relays are so adjusted that they will not trip if the ground is cleared in this time. As the transformers are at some distance from the lightning arresters, another set of fused gaps is located near the transformers on the main bus. Should these blow frequently, thereby giving evidence of reflected waves of a dangerous magnitude, lightning arresters will be installed at

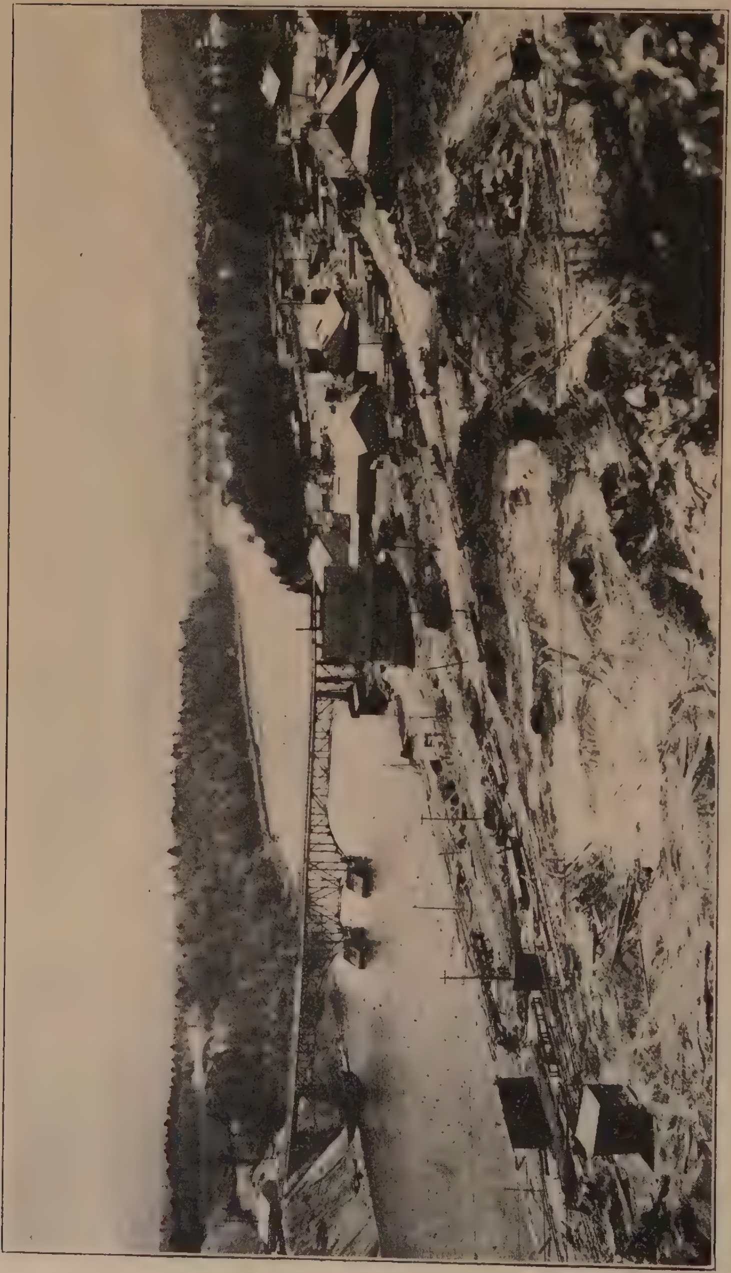

FIG. 8. — GENERAL CONSTRUCTION PLANT

the transformers. As a further protection to the substation apparatus, four ground wires per circuit are carried for three-quarters of a mile from the substation.

A very complete ground system is installed with all apparatus tied to a common ground bus which has numerous leads extending through the dam to damp earth. Coiled wires buried beneath tower footings and driven grounds are also used all over the substation area. The main ground bus is a series of rings with separate feeders from the different classes of equipment, such as transformer neutrals, lightning arresters, etc. The substation and powerhouse grounds are tied together with provision for separating these grounds for testing.

Transmission Lines

At present there are two circuits from this substation, one 67 miles long going to Bucksport, the other 72 miles, to Gulf Island Station near Lewiston, and there tying in with the 110 k. v. system to Farmingdale, Maxcy's and Portland. These lines are of the wood pole H-frame type of construction, using 50-foot minimum height poles and 29-foot wood cross arms giving a wire spacing of 14 feet. The average span is 470 feet, with a maximum of 800 feet on standard construction. The line wires are 266,800 C/M A. C. S. R., strung so as to give a maximum tension under class B loading of 3,750 pounds, or 40 per cent of ultimate. Eight standard 10-inch discs are used in suspension and 10 in tension. Locke, Lapp and O. B. insulators have been used. Two ground wires of ⅜-inch diameter crucible steel are strung over the pole caps on steel extensions. Both these wires are grounded at every pole. The right of way was cleared for a width of 125 feet.

At Bucksport the line crosses the Penobscot River in a 1,680-foot span. The crossing towers are 205 feet to the lowest arm and 247 feet over all, giving a clearance at high tide of 145 feet. The crossing towers are of the suspension type with low dead-end towers. The crossing is designed for three-fourths radial ice and 11 pounds wind, with a liberal safety factor.

General Construction Features

For the construction of the dam a spur track was constructed to the site from the Maine Central Railroad at Bingham. It was necessary to have access to the west side of the river for equipment and materials. For this purpose a steel bridge of 400-foot span was erected. This structure was designed for Cooper's E40 loading or a 75-ton steam shovel. About three miles of narrow gage construction track were also built.

All concrete was mixed in central plants and hauled to the dam in bottom-dump buckets on flat cars. The buckets were swung into place by cranes or derricks.

Concrete aggregate was obtained from a pit about a mile south of the mixing plant on the west side of the river. A screening and washing plant was installed, and all aggregate used was washed. In all, 450,000 tons of aggregate were handled.

In the construction of the dam there were placed 260,000 cubic yards of concrete, 300,000 cubic yards of earth were excavated, there was 195,000 cubic yards of ledge excavation, and 2,500,000 cubic yards of earth fill placed in the dam. The most earth placed in twenty-four hours was 10,600 cubic yards. The maximum number of men employed at one time was about 2,400.

Twelve miles of new Federal aid road was built to replace the old road flooded out on the east side of the river. Fourteen miles of secondary road were built on the west side.

A hydraulic model of the construction waterways and of the spillway was built on a scale of 1: 144, in which conditions of normal and flood flows were studied. Coefficients were determined on larger scale models. To check the accuracy of results, two, and in some instances three, different scale models were made in order to determine the variation in coefficient with the model scale. This work was very carefully done and much valuable information was obtained. The model had a water capacity of 1.5 c. f. s.

The project was designed by the engineering department of the New England Public Service Company, of which Mr. F. H. Mason is chief engineer. Supervision of construction was by the Morton C. Tuttle Company of Boston.

Discussion

Q. How long a time was allowed to decompress the men?

A. That varied with the pressure. The decompression period varied from three minutes up to about thirty minutes. The time for the different pressures is specified by law in those states where such laws are in force. In Maine at the time this work was done there was no state law, and the work was carried on in accordance with the terms of the law of the states of New York and Pennsylvania. A reference to these laws will give all desired information relative to time of decompression and the length of working periods.

Q. How long were the men allowed to work under the maximum pressure?

A. About one hour twice a day.

Q. How were the high pressure types of air tools introduced into the chamber?

A. There was an extra air supply pipe to the working chamber and the air tools were attached at the end of this spare pipe.

Q. Did you strike any boulders with the cutting edge of the caisson?

A. A great many. They were drilled and blasted and the broken pieces brought out.

Q. You said, I think, that the excavation in the working chamber was done by hand?

A. Yes, all by hand.

Q. Was the use of air tools considered to loosen the material?

A. It wasn't necessary. The material was not compacted so much but what pick and shovel excavation was sufficient.

Q. Were there no compressed air tools used in the working chamber?

A. When they were drilling for blasting there were.

Q. Was there any special arrangement for heating the gates?

A. The Broome type of gate is equipped with electric heaters on the sides and the sills. The Tainter gates are not.

Q. When did the station go into operation?

A. The first unit was put on the line for a few minutes as a present to Mr. Wyman on the 24th of December, 1930. It was put on the line for continuous operation on December 28. At that time the pond was not up to its full height. The units were operated during the winter and early spring up to the capacity of the normal flow of the river plus some accumulated storage. Operation was possible up to about the first of April, at which time we shut down and waited for the pond to fill by the spring flood. About the 28th of April the pond was filled to operating stage again, and the station has been in operation ever since.

Q. Were any of the stanchion gates operated during the spring run-off?

A. No, these stanchions are for extremely high flood, and we do not anticipate using either the high or the low stanchions during normal spring run-off.

Q. Are the stanchion gates lifted by crane?

A. No, they have screw and hand-wheel hoists for the operation of the top panel sections.

Q. Was the upstream line of caissons in the river channel tied to the retaining wall?

A. Yes, it was tied to the retaining wall and back into the main caisson line at the shore end. This was done to cut down the seepage to expedite the placing of the earth fill.

Q. Is there any fishway installed at this dam?

A. No, the paper mills located on the stream short distances below this dam have pretty well killed off the fish in the stream. Most of the fishing in Maine is done in the lakes, and less attention is given to streams such as the Kennebec River than to the ponds and lakes by the Fish and Game Association.

Q. How much clearing was done in the storage basin?

A. All trees were cut which would project above the surface of the water at normal pond level, or above the surface at the maximum draw-down level.

Q. What were your assumptions on uplift and ice pressure?

A. For ice pressure we figured 40,000 pounds per linear foot on masonry, and 4,000 pounds per linear foot on gate structures. For uplift we used full head to 0 toe on 50 per cent of the base area. Considerable amount of drilling and grouting of ledge was done along the entire length of the dam to further guard against uplift pressure.

Q. Have you tested the efficiency of these units?

A. No. We have a provision in the waterways for the attachment of flow meters, and have also made provision for the attachment of apparatus for the salt velocity method of calibration. We have not done anything yet in the way of testing.

Q. In the picture of the contractor's plant there was considerable smoke. Did you use electricity for the compressors?

A. Practically all of the contractor's plant was steam operated. We used some gas compressors for the high air for tools. One reason for using steam for the low air was the question of reliability, and another reason was that at the start of the job we did not have sufficient line capacity to provide the power requirements for this equipment.

Q. What was the capacity of the compressor plant?

A. The capacity of the low air was about 5,200 cubic feet per minute, and the high pressure air was about 550 cubic feet per minute.

Q. Did the caisson sections go down at a uniform rate?

A. No, not in the sense that it moved at a slow, continuous rate. As the excavation was carried below the cutting edge the section was usually stationary. After the work had been carried a reasonable distance below the cutting edge additional concrete was placed on top to increase the height of the caisson, and this additional weight sank the section to the new bottom. The concrete was the only weight used for sinking, no rails or other material being necessary.

Q. Was there any difficulty in maintaining steady air pressure in the working chamber?

A. No, the pressure was regulated through valves by the attendant.

Q. Were there any air leaks out of the working chamber?

A. Yes, the material through which the caissons were sunk was so porous that air escaped in considerable quantities at times. When leakage occurred the side walls were plastered with clay and this took care of the situation.

Q. Was the working chamber filled under air?

A. Yes, the working chamber and a short section of the shaft above were filled under air pressure. The balance of the shaft was filled in free air.

Q. What was the elapsed time from the time you started caisson construction till it was finished?

A. I believe the caisson work was started about March, 1929 — it might have been April, 1929. It was completed some time in April, 1930 — about a year.

Q. Why was the log sluiceway? Was it a state ruling? Had the mills below a prior right?

A. That's it. They had a prior right.

Q. Was there any attempt made to grout the rock?

A. No. Where rock showed erosion it was cleaned off to solid ledge. Drill holes were sunk into the ledge a sufficient distance to be certain that the material was ledge and not a large boulder, but no grouting was done.

Q. Did you have any cases of the bends?

A. Yes, there were several cases.

Q. Were there any deaths?

A. Yes, I know of one fatality. In this particular case it was ascertained that the victim was suffering from some ailment which did not show up in his physical examination, because he, at that time, was having treatment by a physician. After commencing work he apparently stopped the treatments and the ailment developed again with fatal results. Work on the caissons was done under the same control as in the states of New York and Pennsylvania, and everything for the prevention and treatment of bends was done at Bingham.

Q. What was the cost of the caisson work?

A. Except for certain sections where extraordinary difficulty was encountered the average cost was about $60 per cubic yard of earth excavated.

Q. During the concreting operations, in raising the height of the caisson section, how was water kept out of the working chamber?

A. Water was allowed to fill the working chamber and the shaft.

Q. How was this water removed when working operations were to be recommenced?

A. Air pressure was applied and the water was forced back into the fill.

Q. How long did it take for this water to be forced out of the inside of the caissons?

A. Not very long. The material in the fill was very porous, and the caissons were emptied in twenty minutes to half an hour.

OF GENERAL INTEREST

ANNUAL DINNER

of the

Engineering Societies of Boston

COPLEY PLAZA HOTEL

February 9, 1932 *Reserve this date*

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

DECEMBER 16, 1931. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7 P.M. by the Vice-President, Ralph W. Horne. About 90 members and guests were present. The usual buffet supper was served to 73 persons.

Announcement was made of the death of Ernest M. Young, who died on November 17, 1931, and who had been a member since April 21, 1920.

The Secretary announced that the following had been elected to membership today by the Board of Government:

Grade of Member: Edwin Blaine Cobb,* Paul F. Howard, Wm. Douglas Lavers,* R. Newton Mayall,* C. Roger Pearson, Arthur N. Roe,* Louis Hart Smith,* Carl Adam Wolfrum.*

Grade of Junior: Joseph Alpert, Gunnar S. Benson, George Henry Bradford, Jr., Joseph Gelsomino Caponigro, Thacher H. Fisk, H. Gordon Martin, John Francis McGrath, Henry Alexander Racicot.

The Secretary reported that at the last meeting (November 18, 1931) a vote was passed regarding the use of the income from the Permanent Fund, and that a similar vote is necessary at this meeting; therefore it was "*voted*, that the Board of Government be authorized to use the income from the Permanent Fund in so far as necessary for the current expenses of the Society."

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* Transferred from Grade of Junior.

The Vice-President, Ralph W. Horne, called upon Prof. Gordon M. Fair to introduce the speaker of the evening, Prof. Kirk Bryan, Associate Professor of Physiography, Department of Geology and Geography and Harvard Engineering School, Harvard University. The subject of his talk was "Geological Problems of Engineering."

He stated that engineering makes its principal although not exclusive contacts with geology in three ways: (1) in its creation of great structures which act as a load on the earth; (2) in the interference with, or utilization of, water circulating in the earth; (3) in the control of natural processes and phenomena, such as coastal erosion, wind action, landslides, rivers, etc.

The problem is (1) to perceive the need for geological facts; (2) to ascertain the facts; (3) to apply this knowledge in formulating the correct and economical design. Obviously, if an engineer is a student of nature, and he should be, many of these problems can be solved without the aid of a geologist. However, in this day of specializing, the services of geologists are being used more and more, particularly in the planning of great projects. Numerous problems, both personal and technical, arise. The growing literature bearing on this relationship is a guide both for the human and technical aspects of this relationship. These points were amplified by descriptions of numerous projects with which Professor Bryan had been connected. Lantern slides were also used.

Discussion and questions followed the talk.

The meeting adjourned at 9 P.M.

EVERETT N. HUTCHINS, *Secretary.*

Sanitary Section

DECEMBER 2, 1931. — At 6 P.M., 22 members and guests dined at Patten's Restaurant.

The meeting was called to order at 7.15 P.M. in the Societies' rooms by the Chairman. The reading of the minutes of the last meeting was omitted, as they have been printed in the JOURNAL.

The paper of the evening was entitled "Occurrence of Iron in Groundwaters of Massachusetts," by John B. Belknap and Clarence I. Sterling, the latter an engineering assistant and the former a past engineering assistant, in the Massachusetts Department of Public Health. The paper was read by Mr. Belknap. The paper described the extent to which iron occurs in Massachusetts, the causes of its increase in certain cases, and its removal from waters.

The paper was discussed by Messrs. Kingsbury, Fales, Doane, Dorr, Pierce, Howard, Eddy, Jr., Fair, Camp and Bogren.

Meeting adjourned at 9 P.M. Attendance, 21.

GEORGE G. BOGREN, *Clerk.*

Designers Section

DECEMBER 9, 1931. — The regular meeting of the Designers Section was held in Chipman Hall on December 9, 1931, and was called to order at 6.10 P.M. by the Chairman, Erwin Harsch. The reading of the minutes of the previous meeting was omitted.

The subject of the evening was a "Discussion of the Proposed Boston Building Code." Four speakers discussed various phases of the subject.

Mr. Edward W. Roemer, Building Commissioner of the city of Boston, spoke on the need for a new code and the method employed in formulating it.

Mr. Paul W. Norton discussed the chapter on dead and live loads, live load reductions, and wind loads.

Mr. Maurice A. Reidy discussed that portion of the proposed code which deals with structural steel and allied topics. He also pointed out the need for the designing engineer's affidavit.

Mr. John R. Nichols spoke on the chapter pertaining to concrete. He pointed out the relation of the proposed requirements to those of standard practice and as required by the present code.

A general discussion followed the talks. One hundred and thirty-five members and guests were present.

The meeting adjourned at 8.10 P.M.

HERMAN G. DRESSER, *Clerk.*

Highway Section

MAY 13, 1931. — The May meeting of the Highway Section was held jointly with the Designers Section in Chipman Hall, and was called to order at 6.05 P.M. by Chairman Harsch of the Designers Section.

The speaker was Benjamin A. Loveland, Assistant Engineer of the Boston Transit Department. He gave a talk on the structural design of the new East Boston Tunnel. Mr. Francis Donaldson, Chief Engineer of the Silas Mason Company, Inc., contractor for the tunnel, also spoke.

The meeting adjourned at 7.25 P.M. The attendance was 108.

ARTHUR P. RICE, *Clerk.*

SEPTEMBER 19, 1931, INSPECTION TRIP. — Sixteen members of the Highway Section met at the State House parking area and left by auto at 1.10 P.M. for the Memorial Drive underpass at Massachusetts Avenue, Cambridge. Details of the design were explained by Mr. Edwin H. Rogers, Director of Park Engineering, Metropolitan District Commission.

Most of the party then drove to Tyngsborough, where they were met by Resident Engineer A. G. Robertson and Mr. Knowlton of Simpson Bros. Co. at the new bridge over the Merrimack River. A sufficient number joined the party at the bridge to make the number the same as at the underpass at Cambridge. Many interesting features of construction were explained by Mr. Robertson, after which the party broke up about five o'clock.

ARTHUR P. RICE, *Clerk.*

NOVEMBER 24, 1931. — The November meeting of the Highway Section was held at the rooms of the Engineering Societies, and was called to order at 6.15 P.M. by Chairman A. B. Edwards.

The paper of the evening, illustrated by lantern slides, on "Traffic Regulation and Control Methods in the Large American Cities," was presented by D. Grant Mickle, Sheldon Traveling Fellow at Harvard University (1931).

A motion was passed directing the Chairman to appoint a nominating committee to select officers for the coming year. The following committee was appointed: J. B. Babcock, R. W. Coburn, J. E. Lawrence.

The meeting adjourned at 8 P.M. The attendance was 39.

ARTHUR P. RICE, *Clerk.*

Northeastern University Section

DECEMBER 10, 1931. — The Northeastern University Section of the Boston Society of Civil Engineers enjoyed a luncheon on December 10, 1931, at the Café de Paris. After the luncheon a meeting was held in Room 23, Huntington Building.

Promptly at 7.15 P.M., Chairman John B. Komich opened the business meeting in which Gunnar S. Benson was elected to a vacancy on the Executive Committee. Nineteen members were present at this meeting.

With the conclusion of the business, the guest speaker, Prof. Henry B. Alvord, was introduced by the Chairman.

Professor Alvord spoke on the triangulation of the Cascade Tunnel in the State of Washington. He related numerous personal experiences in addition to the technical phases in this triangulation.

After an open discussion the meeting was adjourned at 9.20 P.M.

G. S. BENSON, *Secretary, pro tem.*

APPLICATIONS FOR MEMBERSHIP

[Jan. 20, 1932]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

Mork, Carl Lawrence, East Longmeadow, Mass. (Age 20, b. Plymouth, Mass.) He is a student at Northeastern University. During co-operative periods has been employed by Simpson Bros., contractors, Boston, by Cobb, Beesley & Miles of Springfield, and by the Commonwealth of Massachusetts, Department of Public Works. Refers to *H. B. Alvord*, *J. W. Copithorne*, *J. W. Greenleaf*, *J. B. Komich*, *V. L. Stone*.

Venti, Frank, East Boston, Mass. (Age 22, b. Boston, Mass.) Graduate of East Boston High School. Two years at Franklin Union evening school; studied applied science and mathematics, 1927–29; graduate of building course, Lowell Institute; and is now taking an advanced course in testing material, also reinforced concrete design at Lowell Institute. Has been with the Metropolitan Sewerage Division since April, 1930. Refers to *R. W. Loud*, *Dean Peabody, Jr.*, *H. T. Stiff*.

Wilcox, Edward Frederick, Brookline, Mass. (Age 22, b. Torrington, Conn.) Graduate of Torrington High School. Completed a postgraduate course in 1928. Entered Northeastern University in 1929. During co-operative periods has been employed as transitman by Daybert & Mahoney in the summers of 1929 and 1930. Refers to *H. B. Alvord*, *C. O. Baird*, *C. S. Ell*, *J. B. Komich*, *A. M. Pillsbury*.

ADDITIONS

Members

Paul F. Howard, 23 Ingleside Avenue, Winthrop, Mass.

C. Roger Pearson, 32 Brookfield Road, Norwood, Mass.

Ray J. Roche, 134 Front Street, East Braintree, Mass.

Juniors

John F. McGrath, 423 Central Avenue, Milton, Mass.

Henry A. Racicot, 9 Fifth Avenue, Webster, Mass.

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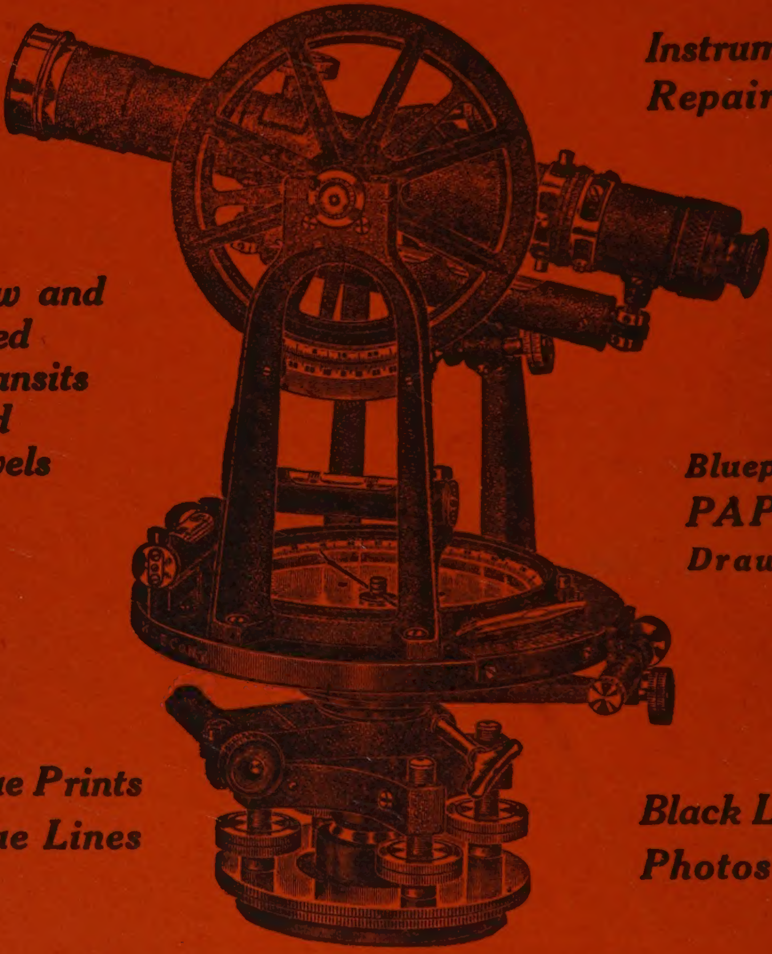

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